Discovery

To Cite:
Adeniran AO, Oyeniran GT, Adeniran AA, Mosunmola MJ. Digitization in logistics and its effect on sustainability in Nigeria. *Discovery* 2024; 60: e15d1420
doi: https://doi.org/10.54905/disssi.v60i334.e15d1420

Author Affiliation:
[1]Federal University of Technology Akure, Ondo State, Nigeria
[2]Georgia State University, Atlanta, United States
[3]University of Ibadan, Nigeria
[4]Ekiti State Unversity, Ado-Akiti, Nigeria

[*]**Corresponding Author**
Federal University of Technology Akure, Ondo State, Nigeria
Email: adeniranao@futa.edu.ng

Peer-Review History
Received: 10 January 2024
Reviewed & Revised: 13/January/2024 to 26/March/2024
Accepted: 30 March 2024
Published: 03 April 2024

Peer-Review Model
External peer-review was done through double-blind method.

Discovery
pISSN 2278–5469; eISSN 2278–5450

© The Author(s) 2024. Open Access. This article is licensed under a Creative Commons Attribution License 4.0 (CC BY 4.0)., which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

Digitization in logistics and its effect on sustainability in Nigeria

Adetayo Olaniyi Adeniran[1*], Gbemileke Tobi Oyeniran[2], Adedayo Ayomide Adeniran[3], Muraina Joseph Mosunmola[4]

ABSTRACT

This study examined the application of digitization in logistics, and its effect on sustainability. As part of the fourth industrial revolution, *most* businesses are currently digitizing. Case study research design was employed by focusing on five e-commerce logistics companies in Nigeria, and it is rooted in qualitative research methods and semi-structured interviews. Seventeen (17) pertinent criteria were identified; of these, ten (out of seventeen) relate to the economic feature of sustainability, two to the environmental feature, and the remaining five to the social feature. The study demonstrated the significant sustainability effect of utilizing digital technologies and applications in logistics within e-commerce logistics companies. Notably, the economic implications of digitization in sustainability effect outweighed the other dimensions, even though participant evaluation of some criteria was ambiguous. It revealed that the social effects of digitalization are often negligible. For labour patterns, digitization was identified to pose a danger. Land-use minimization was the primary effect of digitalization on the environment. Social value will be created by digitization than economic value.

Keywords: Digitizaton; E-commerce; E-commerce logistics; Industry 4.0; Sustainability

1. INTRODUCTION

E-commerce is a business dynamic that allows consumers and organizations to conduct business transactions over the Internet using computers and Internet-Allowed Devices (IEDs). It facilitates the connection between customers and sellers over the Internet rather than dealing with the distribution or actual transportation of goods (Diana et al., 2020). A type of commerce called logistics allows investing in the logistics components and carrying out logistical activities. It is used in many different contexts, including supply chain management, demand planning, warehousing, production, procurement, product flow, marketing, and inventory control. It is used in information and control processing, fleet management, packaging and unitization, efficiency, customer service, delivery processes, and third-party logistics services. It implies that e-commerce is a form of logistics.

From the storage of raw materials to the ultimate distribution of the finished product, logistics is concerned with both physical and information movements (Al-Ashhab & Aldosari, 2022). According to Adeniran et al., (2022) and Xiang, (2014), it is defined as the physical and information flows, storage, and distribution of raw materials to the consumers' doorstep. Information and communication technologies (ICTs) are the driving force behind electronic commerce logistics (e-commerce logistics). This type of logistics can potentially improve trade efficiency globally and integrate emerging countries into a global economy (UNCTAD, 1999). Because of this, Chowdhury, (2003) noticed that e-commerce logistics had significantly increased in the developed countries during the last twenty years, while Adeniran et al., (2022) observed that this was witnessed in the developing countries in the previous ten years. E-commerce logistics is the management of the physical flows of an organization that sells goods via an online platform.

The fourth industrial revolution has sped up the Digitalization process and changed corporate content. It has also made the environment and market structure more dynamic. State that during this digitization process, corporate processes have developed quickly and progressively, current procedures and practices have improved, new technologies have been introduced, and the market has grown significantly in size and scope. The main goal of Industry 4.0 is to apply the Internet of Things (IoTs) and services using emerging information technologies. This will allow business and engineering processes to be closely integrated, allowing for flexible, cost-effective, and environmentally friendly business operations that are always of high quality (Wang et al., 2016; Kanade et al. 2024).

To accomplish the desired goals towards "Intelligent Business", such as absolute transparency in business dealings from suppliers to customers in real time, trim sizes, multiple product variants, connected processes, and decentralized, autonomous management, digital transformation, nonetheless, primarily focuses on business, such as commerce. Intelligent business dynamics cannot be implemented unless the associated logistical operations are likewise intelligent (Kagermann, 2015; Somuyiwa and Adebayo, 2011; Olayimika et al., 2022). To achieve a dependable and sustainable transport and product supply, digitization is a crucial tool. The broad use of intelligent and networked digital technologies and applications (such as mobile, cloud, sensors, data analytics, machine learning, blockchain, and IoT) and improving horizontal and vertical supply chain partner integration provide a clearer perspective on logistics.

A new business paradigm is required to move towards a connected, seamless, intelligent, efficient, and sustainable digital logistics ecosystem that is completely transparent to all parties involved, commencing with the business activities for the supplying of raw materials, components, and parts and ending with the transporting of those supplies and finished goods, which in turn deliver the goods to the customers which are demanding fulfillment. As economics is said to be completed when goods reach the final consumer and are consumed, so also is logistics said to be completed in the entire processes of economics are fulfilled. This is expected to lead to a radical shift in the way that business thinking and implementation in logistics are implemented. Every business and industry engage in activities that release carbon emissions into the atmosphere, which in turn contributes to climate change. They account for about twenty-two percent of total final energy consumption and about twenty percent of global carbon emissions.

This is done through the burning of fossil fuels, releasing chemicals into the atmosphere, reducing the amount of vegetation and forest cover, expansion of development activities among others. During this transformation, matter, energy, and labour into goods, services, waste, and ambient emissions have produced high levels of economic wealth, it also increases human interference with the biosphere (Gebler et al., 2014). The goal of *digitizing* the business sector is the attainment of business transformation (the ability to achieve a more resilient, just, and sustainable operation). This is by the World Commission on Environment and Development (WCED, 1987). It was stated by the World Economic Forum, (2016a) that by 2025, digital technology alone has the great potential to reduce emissions connected to logistics by up to ten to twelve percent and decarbonise the global economy.

Due to, the sustainable digital logistics ecosystem aims to represent the interdependencies between sustainability and maintain a balance among its economic, social, and environmental aspects. To support sustainable development, it also seeks to reconsider digitally based business models and rework business procedures throughout the supply chain (World Economic Forum, 2016a). This study aims to investigate the sustainability effect of logistics digitization, and the characteristics of digitization and related technologies in the logistics network, how the adoption of digitization altered logistics processes, and the benefits that have resulted from digitization, using five e-commerce logistics businesses in Nigeria as a case study?

Literature Review

Business Consciousness on Environmental Practices

Businesses are now more concerned about the environment than they have ever been. As noted by Chen and Kitsis, (2017), Zhu et al., (2013), Chu et al., (2017), most industries have already recognised and valued the environmental management concept. In the past,

businesses only made an effort to refrain from activities that directly broke ecological laws to avoid penalties and prohibitions, such as waste management and satisfying emission requirements (Bag et al., 2021; Fang and Zhang, 2018). Nonetheless, regulations have been tightened by authorities throughout time Liu et al., (2012), and people's understanding of various environmental degradation and protection issues has been a major motivator for everyone to pay attention to the environment (Tseng et al., 2019).

According to Afum et al., (2020), many firms' environmental performance strategies and related activities have undergone considerable changes due to of managerial comprehension of the environmental concept and its realized benefits. According to Geng et al., (2017), awareness fosters an understanding that all supply chain processes (internal and external) have the potential to harm the social or environmental spectrum. Due to, genuine initiatives are needed at every stage of the supply chain, both internal and external. According to Wang et al., (2018), proactive thinking results in value creation through promising environmental interactions.

According to Mohanty and Prakash, (2014), there is a growing need for green supply chain management to address environmental challenges. Applying the green idea within any firm results in both social and financial gain since businesses now view becoming green as a competitive advantage rather than merely a way to improve their corporate image (Yu et al., 2018). Despite being aware of the numerous financial benefits, a sizable portion of supply chain managers still do not prioritize environmental issues, according to (Abu-Seman et al., 2019; Adeniran et al., 2022). The fact that many benefits of eco-friendly innovation are invisible, hence, green supply chain management is not given as much attention.

Digitization in Logistics

To create a digital representation that can be electronically processed or stored, an analogue signal must first be captured and then converted into digital form, a process known as digitization. Information and communication are now accessible to everyone, wherever, at any time, through any device, and any kind of access due to of digitization. A growing amount of recorded information has gone digital due to the increased usage of computer technology. In 1993, just 3% of all recorded information worldwide was saved digitally; by 2007, that number had risen to 94% (Stuermer et al., 2017).

A network, as an entire supply chain or a single logistics process, becomes more digitally connected. Better data and transactions are captured and processed, the more intelligent systems are added, and the more these systems communicate through connections. According to Digitalization partially or disrupts logistical operations, but it also can potentially provide intrinsic value for the sector and society at large. To provide customers with the most efficient and transparent service delivery, building a logistics network with digital technologies would allow businesses to step up their competition and offer a new level of resiliency and responsiveness. This is because analytic technology, such as hyper-connectivity, supercomputing, or big data, obtains large-scale logistics data, and applying complex algorithms to this data helps businesses find areas where they can increase profit margins.

A white paper published by the World Economic Forum suggests that by 2025, logistics Digitalization may generate $1.5 trillion in value (World Economic Forum, 2016a). Technology, process, organization, and knowledge are the four main allowrs that form the foundation of the digital logistics ecosystem (Stuermer et al., 2017). Digital logistics strategies must succeed by combining technology and apps with sound knowledge management throughout businesses and business processes. Six characteristics which are connectedness, cooperation, integration, adaptiveness, cognitive improvement, and autonomous control are the foundation of logistics Digitalization.

The complete integration of a broad range of digital technologies, including data analytics, cloud, mobile, augmented reality, Internet of Things, sensors, and three-dimensional (3D) printing into logistics processes enhances the advantages of:

Spare parts management;

Logistics visibility;

Intelligent procurement and warehousing, advanced analytics, and

Autonomous logistics.

The following six attributes of a digital logistics design, along with the technology at hand, offer major advantages for organizing, scheduling, and managing freight and logistics operations:

Autonomous decision-making;

Making a whichle customer experience possible with augmented reality technologies such as wearable computing;

Cloud computing-based information collection that is location- and device-independent;

Reducing failures in complex processes;

Improved automation via interaction between humans and machines;
Low management complexity through decentralized approaches;
Efficiency and visibility for logistics centres and transportation networks;
Software architecture and open intelligent user interface that facilitates collaboration both vertically and horizontally;
Complete transparency across the supply chain;
Real time operations; and
Increased potential for optimisation using big data analytics.

Furthermore, by using "what-if scenario analysis" to model the system, these digital technologies allow businesses to foresee potential hazards and adjust logistical procedures in real time in response to supply chain interruptions. The entire planning, organizing, sourcing, manufacturing, controlling, delivering, and returning processes will be Digitalised completely; this will save lead times and allow swift workflows. Understanding how digitization affects logistics from the standpoint of the social, environmental, and economic facets of sustainability can provide insight into the logistics ecosystem that is digitally driven towards sustainability. The following should be reflected in the sustainability features:
The social feature of digitized logistics*:* Digitized logistics makes it easier for people and communities to obtain basic requirements, meet those needs securely, and promote high-quality lifestyles without jeopardising intergenerational and intragenerational fairness.
Environmental feature of digitized logistics: Digitalised logistics employs technology that reuses and recycles its components, minimizes the use of non-renewable energy sources, and minimizes greenhouse gas emissions, pollution, and waste.
The economic feature of digitized logistics: Digitalised logistics allow the usage of cost-effective systems that function effectively, provide joint solutions and various transport mode options, and boost the local economy may be used. The comprehensive descriptions and features of digitization in logistics are:

Cooperation

The World Economic Forum, (2016a) states that cooperative action through digitization, for instance, the shared storage and transportation system will boost the logistics sector's reliability and efficiency. Due to this, there are particular requirements for data integration, information sharing across organizations, and design support for virtual logistics clusters. To use logistical services outside their operational boundaries, virtual service providers form strategic alliances with other businesses and partners, allowing them to share their physical infrastructure (Chang et al., 2006). This is predominant in the airline business. An example of this would be the utilisation of a digitally linked cross-border logistics hub to aggregate storage and transportation resources over a vast geographically dispersed region of operation. The core of a digital operational model is the use of digital capabilities across information technology, data and performance management, procedures, governance, and processes. It permits the necessary degrees of process standardization and integration (Raab and Griffin-Cryan, 2011).

Connectivity

In this case, the term "technology" refers to the ability of a resource to accept a connection from another resource or to act as an interface to other digital resources on the network. Vertical integration, made possible by digitization through connectivity, from supplier to customer, and horizontal integration between competitors and other business partners throughout the supply chain, may preserve end-to-end visibility. Businesses can balance supply and demand for underutilized products and assets because of technologies like machine-to-machine (M2M), hyper-connectivity, super-computing, and real time big data analytics. Social media, intelligent phones, and cloud computing may dematerialize whichle sectors or individual items. By using automated mechanisms to prevent mistakes and unforeidentified disruptions, the logistics system is made more intelligent and productive. Furthermore, according to Lacy and Ritqvist, (2015), 3D printing opens up possibilities for producing inputs that are eternally recyclable or biodegradable, such as coco-pallet.

Adaptiveness

A system that is open, dynamic, and adaptable is called digitization. It is defined by the fact that its constituent parts and their relationships may change over time and that external events can effect it. According to the networked digital resource system is both flexible enough to be altered by an external actor, such as a graphical user interface, and self-adaptive, meaning it adjusts itself in

response to perceived changes in the environment, such as user input or modifications to the internal structure of the system. Intelligent bins or containers can be configured to use various sensors for tracking and tracing.

Integration

In the context of the digital economy, this refers to a system's capacity to connect, integrate, monetize, and share any type of data, device, system, or process in close to real time. The integration of information technology and logistics systems is the functionally and physically linking many software programs and computer systems to function as a coherent, well-coordinated whichle. The interconnections between the logistical subsystems give it extra value. Integrations of three kinds are feasible:

Value networks attained through horizontal integration;

Networked logistics systems and vertical integration; and

End-to-end digital integration of logistics throughout the value chain (Wang et al., 2016).

Software as a Service (SaaS) applications and other digital service platforms that allow communication between back-end systems of organizations allow the seamless integration of cloud, mobile, and other application programming interface (API) digital ecosystems with traditional data centres and enterprise services. Using this system logic, digitally allowed global logistics platforms are built up to link all users (shippers, logistics providers, etc.) and maintain a real time working environment. These platforms combine the demands of several shippers, streamlining the which logistics planning process and recommending the best modes of transportation depending on the location of the warehouse and the intended delivery point (World Economic Forum, 2016a).

Autonomous control

Decentralized, independent decision-making is made possible by digitization. To be autonomous means to act on one's initiative and without external supervision. Transvoyant is one example of a machine-learning technology that aids with predictive analytics. Sensors, satellites, radar, video cameras, and intelligent phones may all be used to gather and analyze many real time events that occur every day. An algorithm is used in logistics systems to monitor the flow of goods in real time while estimating the arrival time and accounting for port traffic, natural catastrophes, and weather. Adidas is employing analytics to allow customers to purchase products in several ways such as online and in-store, and have them delivered in any way including home, store, or at a pick-up location. This is known as an omni-channel approach.

Cognition

Logistics activities are changing significantly due to of the introduction of technologies such as artificial intelligence (AI), robots, and drones for managing the domestic and international movement of goods. The performance of the logistics business both now and in the future is greatly influenced by many technologies and applications, including autonomous mobile robots, crewless aerial vehicles, crewless ground vehicles, and self-driving automobiles. Additionally, autonomous cars have a more significant potential to improve road safety and reduce accidents. Automakers including Daimler, Volvo, and Scania are exploring self-driving trucks; Google's driverless automobile is making significant strides; and Uber completed the first autonomous delivery operation.

For large deliveries, Amazon is constructing flying warehouse blimps and investigating the feasibility of using drone technology to carry tiny goods. Nonetheless, this technology has attained a level of maturity in warehouse operations. Additionally, picking processes using autonomous forklifts are increasing productivity in warehouse logistics. In contrast, drones will generate $20 billion in business effect from faster and less expensive last-mile delivery services in rural and urban areas. These figures are based on a white paper published by the World Economic Forum (World Economic Forum, 2016a). Autonomous trucks are expected to save $30 billion in fuel, maintenance, employee, and insurance costs.

2. METHODS

This study adopts a qualitative case study research method using a Delphi panel to examine five e-commerce logistics businesses in Nigeria. Case study methodological design was used to assess how Digitalization in logistics affects sustainability, emphasizing comprehending the dynamic existing in a particular situation (Yin, 2014). To prepare them for rapid adaptation in the face of shifting customer behavior, particularly with the development of digital, the case study is conducted inside five e-commerce logistics firms in

Nigeria. To determine the qualitative effects of digitization on the economy, environment, and society such as the three sustainability aspects of logistics, as described by the WCED, (1987), is a descriptive sustainability evaluation.

A preset set of criteria is used to base the evaluation; the implications of these criteria were identified and discussed. Qualitative approach is suitable for social indicators because digitalization technologies are still in their infancy. On the other hand, energy, expenses, and carbon emissions may be used to quantify the different economic and environmental variables. Nevertheless, because it was difficult to get representative data for this study, all sustainability parameters were assessed subjectively. Due to the lack of a comprehensive sustainability assessment of the digitalization of logistics, and the fact that prior research on sustainability dimensions has concentrated chiefly on transportation as opposed to logistics, the criteria were gathered by reading pertinent literature and consulting with experts (Monnet and Le-Net, 2011).

As indicated in Table 1, a feature has been deemed suitable to serve as criteria if it has a sustainability effect connected to Digitalization in logistics. Seventeen (17) pertinent criteria were identified in due course; of these, ten (out of seventeen) relate to the economic feature of sustainability, two to the environmental feature, and the remaining five to the social feature. The digitization features are considered while making decisions on the listed factors, to assess the effect of digitization from a logistical viewpoint.

Table 1 Standards by which the sustainability implications of the digitalization of logistics

Sustainability Features	Sustainability Criteria	Description	Source
Economy	Logistics cost	Modifications to the cost-saving measures for transportation, storage, carrying inventory, and administration.	Monnet and Le-Net, (2011), Dougados et al., (2013), Gebler et al., (2014), World Economic Forum, (2016a)
	Delivery time	Modifications to delivery improvements, cycle time, and lead time.	Monnet and Le-Net, (2011), Dougados et al., (2013), Raab and Griffin-Cryan, (2011), World Economic Forum, (2016a)
	Transport delay	Modifications to the amount of delayed shipment.	Monnet and Le-Net, (2011), World Economic Forum, (2016a)
	Inventory reduction	Modifications to inventory volume.	Dougados et al., (2013)
	Loss or damage of goods	Adjustments to the quantity of lost or damaged products due to of mishaps, theft, and damage.	Monnet and Le-Net, (2011)
	Frequency of service	Regular interval adjustments to the utilisation rate (load factor).	Dougados et al., (2013)
	Accuracy of forecast	Modifications to demand uncertainties.	Dougados et al., (2013)
	Reliability of service	Alterations to the level of logistics quality concerning shipping, stock, and storage, such as flawless order and on-time delivery.	Monnet and Le-Net, (2011), Dougados et al., (2013), Gebler et al., (2014), World Economic Forum, (2016a)
	Volumes of freight	Modifications to total transported freight volume	Monnet and Le-Net, (2011)
	Use of applications	Applications that make sense for *digitizing* logistical procedures.	Gebler et al., (2014), World Economic Forum, (2016a)
Environment	Resource efficiency	Usage of automobiles and transportation infrastructure that depletes nonrenewable resources.	Monnet and Le-Net, (2011) Gebler et al., (2014),

	Land use effect	Changes to the amount of land used for transportation and the pace of land loss.	Monnet and Le-Net, (2011)
Society	Development benefits	Implications of technology for sustainable development.	Gebler et al., (2014)
	Health	Effects on health brought on by logistical digitization.	Gebler et al., (2014)
	Safety	Changes to the number of fatalities and disability resulting from accidents.	Monnet and Le-Net, (2011), World Economic Forum, (2016a)
	Labour patterns	Modifications to labour intensity, employment schemes, and work types.	Monnet and Le-Net, (2011), Gebler et al., (2014)
	Acceptance	Acceptability of digital applications in the society, economy, and market.	Gebler et al., (2014)

3. RESULT

Following the identification of a set of standards for the sustainability effect of digitalization in e-commerce logistics, a case study involving e-commerce logistics firms is investigated. Five e-commerce logistics organizations were chosen for this study because, in addition to collaborating in logistical activities, they are investing in digital transformation and implementing the newest digital technologies and applications in their business operations. Some of these indices were applied in the study of. To complete the table, questions were asked from experts in each of the logistics firms for the subject matter. *How do you evaluate the sustainability effect of digitization in logistics processes and operations for digitization characteristics of logistics*? Please rate each of the following statements on a five-point scale based on your experience in the firm: 000, *high* 00 *moderate,* 0 *less, no effect, n/a no available evidence yet*.

Following the establishment of a set of standards for the sustainability effect of digitization in e-commerce logistics, a case study involving e-commerce logistics firms is investigated. Five e-commerce logistics organizations were chosen for this study because, according to they are collaborating on logistics projects, investing in digital transformation, and incorporating the newest digital technology and apps into their operations and procedures. To complete the table, the following questions were posed to expert in each of the logistics firm. Please rate each of the following statements on a five-point scale based on your experience in the firm: "*In light of the characteristics of logistics digitization, how do you assess the sustainability effect of digitization in logistics processes and operations?"*

4. DISCUSSION

The findings demonstrated the significant sustainability effects of digital technologies and application usage on logistics operation within e-commerce logistics firms (Table 2). Notably, the economic implications of digitization's sustainability effect outweighed the other dimensions, even though participant evaluation of some criteria was ambiguous. Digitization of logistics has a tremendous deal of promise regarding concerns related to cost, delivery time, delay, inventory, dependability, and flexibility. In addition, research revealed that the social effects of digitization such as better health outcomes and fewer accidents have largely had little effect. The digitalization of logistics might alleviate safety and health issues, but it was first perceived as a threat to labour patterns, which reduced complete digitization.

Land-use minimization was the primary effect of digitalization on the environment. Due to, entrepreneurs, regulators, and policymakers will need to work together to maximise value for both business and broader society without compromising the Land-use, thereby factoring in the contributions of green environment. It is anticipated that digitization will produce significantly more value for society than for the economy.

Table 2 Stainability implications of the digitalization of logistics across the five selected e-logistic firms in Nigeria

Sustainability Features	Sustainability Criteria	Digitization Characteristics					
		Cooperation	Connectedness	Adaptiveness	Integration	Autonomous Control	Cognitive Improvement
Economy	Logistics cost	🟢🟢	🟢🟢🟢	🟢🟢	🟢🟢	🟢	🟢
	Delivery time	🟢🟢🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢🟢	🟢🟢
	Transport delay	🟢🟢🟢	🟢🟢	-	🟢🟢🟢	🟢🟢	🟢
	Inventory reduction	🟢🟢	🟢🟢	🟢	🟢🟢🟢	🟢🟢	🟢🟢
	Loss or damage of goods	🟢🟢🟢	🟢	n/a	🟢🟢🟢	🟢	🟢🟢
	Frequency of service	🟢🟢	🟢🟢	🟢	🟢	🟢🟢	🟢🟢
	Accuracy of forecast	🟢🟢🟢	🟢🟢🟢	🟢🟢	🟢	🟢🟢	🟢🟢
	Reliability of service	🟢🟢🟢					🟢🟢
	Volumes of freight	🟢	🟢	-	🟢🟢	🟢	🟢🟢
	Use of applications	🟢🟢	🟢🟢	🟢🟢🟢	🟢🟢	🟢🟢🟢	🟢
Environment	Resource efficiency	🟢🟢🟢	🟢🟢	🟢	🟢🟢	🟢🟢	🟢🟢
	Land use effect	🟢🟢🟢	🟢🟢🟢	🟢🟢	🟢🟢🟢	🟢🟢	🟢🟢
Society	Development benefits	🟢	🟢🟢	🟢	🟢	🟢🟢	🟢🟢
	Health	🟢🟢	🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢
	Safety	🟢🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢
	Labour patterns	🟢	🟢	🟢	🟢	-	-
	Acceptance	🟢	🟢	🟢	🟢🟢	🟢	🟢

Denotations: 🟢🟢🟢; *High* 🟢🟢; *Moderate* 🟢; *Less, No effect; n/a No available evidence yet*.

5. CONCLUSIONS

As part of the fourth industrial revolution, most businesses are currently digitizing. Since commerce is the primary focus of the digital revolution, phrases such as "Commerce of the Future" and "E-Commerce" are used interchangeably with this idea. Nonetheless, there are several justifications for thinking about how digitization will affect e-commerce logistics (ECL) and how crucial the supply chain will be for Industry 4.0. The main benefits of this idea include trimer batch sizes, numerous product variations, networked processes, real time complete transparency from suppliers to customers, and decentralized, autonomous management. Additionally, e-commerce logistics need to have a clearer vision to use relevant technology and improve both vertical and horizontal supply chain partner integration to meet industry 4.0 criteria as sustainably as feasible. This study investigates the sustainability effect of digitization in e-commerce logistics while highlighting the advantages of digitizing the process.

The study provided answers to questions about what digitization characters and related technologies are in the logistics network, how the adoption of digitization altered logistics procedures, and which benefits have been realized due to of digitization. Most the literature that has already been written has discussed the implications of digitization for sustainability only from the standpoint of

transportation, failing to take a comprehensive view of logistics. Consequently, this study offers a fresh method for comprehending the consequences of sustainability from a logistical standpoint. Since logistics digitization is still in its early stages of development, it has not yet attained maturity. Because of this, the implications of sustainability may be enhanced and modified as digitalization matures. The study demonstrated the significant sustainability effect of using digital technologies and applications in logistics within e-commerce logistics companies.

Notably, the economic implications of digitization in sustainability effect outweighed the other dimensions, even though participant evaluation of some criteria was ambiguous. Digitization of logistics has a tremendous deal of promise regarding concerns related to cost, delivery time, delay, inventory, dependability, and flexibility. Aside from this, research indicated that the social effects of digitization such as better health outcomes and a decrease in accident occurrence have little bearing on society overall. While the Digitalization of logistics might alleviate safety and health issues, it was less accepted when it came to complete digitization since it was perceived as a threat to labour patterns.

Land-use minimization was the primary effect of digitalization on the environment. Due to, entrepreneurs, regulators, and policymakers will need to work together to maximise value for both business and broader society without compromising the Land-use, thereby factoring in the contributions of green environment. It is anticipated that digitization will benefit society far more than the economy. The study's limitations limit how broadly the findings may be applied. For example, only five e-commerce logistics organizations participated in the Delphi survey. Additionally, the study lacked a quantitative component and was only evaluated qualitatively on the three sustainability aspects of economy, environment, and society.

Abbreviations

ECL: Electronic commerce logistics
ICTs: Information and Communication Technologies
IEDs: Internet-Allowed Devices
Industry 4.0: Fourth Industrial Revolution
IoT: Internet of Things
WCED: World Commission on Environment and Development

Author Contributions

AOA designed the introduction, literature, and methods, analyzed the data, and and proofread the article, GTO designed the literature, AAA gathered data; MJM coded the gathered data. All authors read and approved the final manuscript.

Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Funding

The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES

1. Abu-Seman NA, Govindan K, Mardani A, Zakuan N, Mat Saman MZ, Hooker RE, Ozkul S. The Mediating Effect of Green Innovation on the Relationship Between Green Supply Chain Management and Environmental Performance. J Clean Prod 2019; 229:115-127. doi: 10.1016/j.jclepro.2019.03.211
2. Adeniran AO, Akinsehinwa FO, Olorunfemi S. Factors influencing the acceptance and patronage of e-commerce logistics operations in Nigeria. Bull Natl Res Cent 2022; 46 (128):1-9. doi: 10.1186/s42269-022-00816-x
3. Afum E, Osei-Ahenkan VY, Agyabeng-Mensah Y, Amponsah-Owusu J, Kusi LY, Ankomah J. Green Manufacturing Practices and Sustainable Performance among Ghanaian Manufacturing SMEs: The Explanatory Link of Green Supply Chain Integration. Manag Environ Qual: Int J 2020; 31(6):1457-1475. doi: 10.1108/MEQ-01-2020-0019
4. Al-Ashhab MS, Aldosari N. Modelling and Solving a Sustainable, Robust Multi-Period Supply Chain Network for Perishable Products. Indian Journal of Engineering 2022; 19(51):184-195
5. Bag S, Pretorius JHC, Gupta S, Dwivedi YK. Role of Institutional Pressures and Resources in the Adoption of Big Data Analytics Powered Artificial Intelligence, Sustainable Manufacturing Practices and Circular Economy Capabilities. Technol Forecast Soc Change 2021; 163:120420. doi: 10.1016/j.techfore.2020.120420
6. Chang E, West M, Hanzic M. A digital ecosystem for extended logistics enterprises. e-Networks in an Increasingly Volatile World. Proceedings of the 11th International Workshop on Telework, 2006; 32-40.
7. Chen IJ, Kitsis AM. A Research Framework of Sustainable Supply Chain Management: The Role of Relational Capabilities in Driving Performance. Int J Logist Manag 2017; 28(4):1454-1478. doi: 10.1108/IJLM-11-2016-0265
8. Chowdhury A. Information technology and productivity payoff in the banking industry: evidence from the emerging markets. J Int Dev 2003; 15(6):693-708. doi: 10.1002/jid.1027
9. Chu SH, Yang H, Lee M, Park S. The Effect of Institutional Pressures on Green Supply Chain Management and Firm Performance: Top Management Roles and Social Capital. Sustainability 2017; 9(5):764. doi: 10.3390/su9050764
10. Diana M, Pirra M, Woodcock A. Freight distribution in urban areas: a method to select the most important loading and unloading areas and a survey tool to investigate related demand patterns. Eur Transp Res Rev 2020; 12:40. doi: 10.1186/s12544-020-00430-w
11. Dougados M, Ghioldi S, Van-Doesburg R, Subrahmanyam KVJ. The Missing Link Supply Chain and Digital Maturity. Capgemini Consulting, White Paper, 2013.
12. Fang C, Zhang J. Performance of Green Supply Chain Management: A Systematic Review and Meta Analysis. J Clean Prod 2018; 183:1064-1081. doi: 10.1016/j.jclepro.2018.02.171
13. Gebler M, Schoot-Uiterkamp AJM, Visser C. A global sustainability perspective on 3D printing technologies. Energy Policy 2014; 74:158-167. doi: 10.1016/j.enpol.2014.08.033
14. Geng R, Mansouri SA, Aktas E. The Relationship between Green Supply Chain Management and Performance: A Meta-Analysis of Empirical Evidences in Asian Emerging Economies. Int J Prod Econ 2017; 183:245-258. doi: 10.1016/j.ijpe.2016.10.008
15. Kagermann H. Change through Digitization - Value Creation in the Age of Industry 4.0. In H Albach, H Meffert, A Pinkwart, R Reichwald (Eds.), Management of Permanent Change Springer Gabler, Wiesbaden, 2015; 23-45. doi: 10.1007/978-3-658-05014-6_2
16. Kanade A, Ranganthan CS, Babu AJ, Ramachandran G, Kusuma AK, Anand M, Reddy DVL. Analysis of wireless network security in internet of things and its applications. Indian Journal of Engineering 2024; 21:e1ije1675
17. Lacy P, Ritqvist J. Waste to wealth: The circular economy advantage. Palgrave Macmillan 2015.
18. Liu X, Yang J, Qu S, Wang L, Shishime T, Bao C. Sustainable Production: Practices and Determinant Factors of Green Supply Chain Management of Chinese Companies. Bus Strategy Environ 2012; 21(1):1-16.
19. Mohanty RP, Prakash A. Green Supply Chain Management Practices in India: A Confirmatory Empirical Study. Prod Manuf Res 2014; 2(1):438-456. doi: 10.1080/21693277.2014.921127
20. Monnet JM, Le-Net N. Assessment of logistics concept to sustainability: Development of a common approach to transport issues. Deliverable D3.3.3, EFORWOOD Project, European Forest Institute, 2011.
21. Olayimika SE, Peter BA, Ibrahim K. Examination of the Maintenance Management Effectiveness in an Industrial Plant. Indian Journal of Engineering 2022; 19(51):116-124
22. Raab M, Griffin-Cryan B. Digital Transformation of Supply Chains, Capgemini Consulting. White Paper 2011.
23. Somuyiwa AO, Adebayo T. Analysis of Information and Communication Technologies (ICT) Usage on Logistics

Activities of Manufacturing Companies in Southwestern Nigeria. JETEMS 2011; 2(1):68-74
24. Stuermer M, Abu-Tayeh G, Myrach T. Digital sustainability: basic conditions for sustainable digital artefacts and their ecosystems. Sustain Sci 2017; 12(2):247-262.
25. Tseng ML, Islam MS, Karia N, Fauzi FA, Afrin S. A Literature Review on Green Supply Chain Management: Trends and Future Challenges. Resour Conserv Recycl 2019; 141:145-162.
26. UNCTAD (United Countries Conference on Trade and Development). Can electronic commerce be an engine for global growth? Electronic commerce and the integration of developing countries and Countries with economies in transition, International Trade. Geneva: UNCTAD 1999; 19–23.
27. Wang J, Zhang Y, Goh M. Moderating the Role of Firm Size in Sustainable Performance Improvement through Sustainable Supply Chain Management. Sustainability 2018; 10(5):1654. doi: 10.3390/su10051654
28. Wang S, Wan J, Li D, Zhang C. Implementing intelligent factory of industrie 4.0: an outlook. Int J Distrib Sens Netw 2016; 12(1). doi: 10.1155/2016/3159805
29. WCED. Our Common Future. World Commission on Environment and Development. Oxford University Press, Oxford, UK 1987.
30. World Economic Forum. Digital Transformation of Industries: Logistics Industry. White Paper 2016a.
31. Xiang L. Operations management of logistics and supply chain: issues and directions. Discrete Dyn Nat Soc 2014; 7. doi: 10.1155/2014/701938
32. Yin RK. Case Study Research Design and Methods (5th ed., 282 p.). Thousand Oaks, CA: Sage 2014. doi: 10.3138/cjpe.30.1.108
33. Yu Z, Abdul S, Khan R. The Relationship between Green Supply Chain Performance, Energy Demand, Economic Growth and Environmental Sustainability: An Empirical Evidence from Developed Countries. LogForum 2018; 14(4):479-494.
34. Zhu Q, Sarkis J, Lai K. Institutional-Based Antecedents and Performance Outcomes of Internal and External Green Supply Chain Management Practices. J Purch Supply Manag 2013; 19(2):106-117. doi: 10.1016/j.pursup.2012.12.001